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Smart Meter docket #E-00000C-11-0328

To Whom It May Concern:

This filing for the Smart Meter docket #E-00000C-11-0328 contains an original filing plus 13 copies and is being filed on behalf of the Safer Utilities Network.

Included in this filing are two comments from the Safer Utilities Network concerning power line communications and a report on power line communications in Japan. Please review these submissions for their relevance to the smart meter docket #E-00000C-11-0328.

Sincerely,

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Docket No. E-00000C-11-0328 Smart Meters

Power Line Communication turns electrical wires into antennas

Power line communication uses existing power lines and household wiring for communication. An unintended consequence of these systems is that they turn the power lines into antennas that radiate into homes from the outside, and also from the wires within a home.

What is power line communication?

Power line communication (PLC) uses existing power lines and household wiring for communication. It is used for a variety of functions, such as computer networking, utility control systems and smart grid.

In some areas, PLC is used to provide internet services to households and small businesses. This is often referred to as Broadband over Powerlines, BPL or BB-PLC.

Some utilities use PLC to remotely read their electrical meters and are experimenting with various smart grid functions to control appliances in the household, also using PLC.

Power companies have used PLC for decades to control remote switching stations and other equipment, by sending PLC signals over long distances on their high-voltage transmission lines. The utilities refer to their use of PLC as Power Line Carrier (also PLC). PLC is called PLT (Power Line Technology) in some countries.

Unintentional antennas

When electrical signals travel along a wire, that wire will radiate the signals into the air. This can sometimes make electronic equipment malfunction, which is referred to as Electromagnetic Interference (EMI). The engineering specialty that deals with these kinds of problems is called EMC (Electromagnetic Compatibility). [1, 2]

Cables intended for data communication such as coax, telephone wires and twisted-pair are all designed to limit the antenna effect.

The electrical wires inside a house and along the street were not designed this way, as they were never intended to carry communication signals. It is even common for wires on poles to be separated from each other, which enhances the antenna effect. The miles of electrical wires in a neighborhood can act as a very large antenna.

Using household wires as antennas

In a few cases, the wires in a home are used as intentional antennas. The most common use is by electricians who need to locate hidden wires. They plug a small device into an outlet, which sends signals out onto the household wires (usually in the lower kilohertz range). The electrician then uses a small handheld wireless receiver to locate the wires.

Another use is PowerLine Positioning (PLP).[3] This can be used to locate people in a building, if they wear special tags which receive the signals from the wiring in the walls.

Household wires are sometimes used to transmit the wireless signals of a small local AM radio station. These are called carrier current stations[9], and typically serve student housing on a college campus.

PLC systems as transmitters

The early PLC systems used low frequencies, which were not a problem for telecommunication. As faster PLC systems were introduced, they started using higher frequencies that were getting close to those used for telecommunication. Users of short wave radio (HAM radio), emergency services and radio astronomy became concerned that the PLC signals would spill up into the bands they were using, causing interference.

Radio amateurs started complaining about interferences with their radios. The PLC industry responded by denying there were any problems at all.[4]

A spokesperson for a PLC vendor with operations in Ohio and Maryland stated that:

> [Interference] just doesn't exist.[5]

However, an IEEE engineering paper on the subject simply states:

> Power cables can be considered linear antennas . . . Whenever PLC signals overlay frequency ranges of wireless services, interference may occur.[6]

Another research paper, published by the British Broadcasting Corporation, states:

> there is the difficulty for radio-system users that the signals [PLC] injects do not simply travel from point to point along the wiring, they also escape as *radiated emissions* [emphasis in original][4]

The authorities get involved

The British Broadcasting Corporation (BBC) got concerned and started looking into the issue. The BBC World Service broadcasts shortwave radio world wide in many languages, especially to countries which do not have a free press. PLC could hamper the reception of these broadcasts.

Since the PLC industry continued to claim that there was no antenna effect, a BBC engineer produced a very elegant demonstration that a widely available PLC system (HomePlug) could be used as a wireless network.[4]

The Federal Communications Commission in the United States looked into PLC after receiving complaints from radio amateurs. The FCC Laboratory measured the radiation from seven PLC systems. The engineers picked up wireless signals from all seven systems. One system violated the FCC radiation limit, while two others reached the limit.[7]

The NATO military alliance became concerned that PLC may interfere with military communication and intelligence gathering. A research task group was assigned to study the issue. The group found that the radiation from both the power lines, as well as in-home wiring could become a problem:

> These increased [RF] levels would have an adverse effect on military communications and COMINT [intelligence] systems . . .[8]

The group also found that buried power lines would dampen the radio frequency radiation by a factor of 3000 (35 dB), compared to a typical overhead power line.

The Japanese government funded a study to determine if PLC systems would interfere with civilian and military communications, as well as with radio astronomy. An elaborate test was created, with a power line dedicated to the

experiment. Wireless receivers were then used to detect the signals at various distances from the power line.[10]

The Japanese scientists found significant radio interference from the test site and recommended that the government disallow PLC systems to operate at higher frequencies. The government agency concurred, and PLC is today prohibited in Japan for frequencies above 450 kHz.[6, 11]

The Swiss Federal Office of Communication investigated the radiation from a commercial PLC system that brought internet service to the city of Fribourg.[13] They found that the radiation levels were above the German NB30 limit.

The telecommunication authority of Austria investigated complaints from emergency services and radio amateurs in the city of Linz. They found that the PLC system providing internet service there exceeded the guidelines and that even the street lights acted as antennas.[15]

These examples of controlled studies in laboratories and measurements on installed PLC systems clearly demonstrate the antenna effect.

The British Electromagnetic Compatibility Industry Association (EMCIA) asked the British authorities to disallow broadband PLC in Great Britain, citing wireless interference.[16] Other parties also weighed in.[8, 17] PLC was allowed in Great Britain, but with significant restrictions. The situation is similar in several other countries in Europe.

Low frequency PLC

The antenna effect is there regardless of the frequency. It is not only in the higher radio frequency and microwave bands that power lines act as unintentional antennas. But, it is only at the higher frequencies that there is a problem for commercial and military communications, as well as for radio astronomy, so that is the area that is studied and regulated.

The lower frequencies are not used much for telecommunication because the transmission speed is much lower. However, the lower frequencies carry much further distances. The U.S. Navy uses low frequency transmitters to communicate with submerged submarines, for instance. These are mostly around 20 kHz, though they go as low as 76 Hertz.[18]

Marine radios and navigation systems go as low as 10 kHz.[18]

These users do not appear to be concerned about PLC systems, perhaps because of the distances to ships at sea.

During World War II, scientists considered using the emissions from the 50 Hertz power lines in Nazi Germany as navigational beacons for Allied bombers, but better systems were developed.[19]

A research institute under the Italian Ministry of Health did look at some of the early PLC systems.[21] They found that the systems operated in the frequency bands from 112 kHz to 370 kHz and could be clearly detected 100 meters (300 ft) from power lines. The authors wondered if the presence of a PLC system or not could explain why some studies showed health effects from living near a power line, while others showed no effect.

Regulation of PLC radiation

Following various investigations and recommendations by scientists, government agencies, the military and other interests, the governments in Europe and Japan have put restrictions on the amount of radiation that is acceptable from PLC systems.[6, 8, 11] These restrictions are only for the frequencies that are also used for wireless communication.

In the United States, there are presently no specific restrictions for PLC systems, only a general one. The situation in the U.S. is characterized in one paper as:

> FCC . . . can be regarded as highly generous for high speed PLC and in no way obstructing the spreading of PLC technology.[6]

The FCC is the Federal Communications Commission, which has the legal authority to regulate wireless transmissions in the United States. That the FCC is much more lenient towards PLC radiation than other entities is demonstrated by various graphical comparisons.[6, 8]

How far does the PLC radiation reach?

The radiation level drops with the distance to the antenna. Since virtually every wire in a house and near a house can become a PLC antenna, it can be difficult to get some distance from all sources.

It is possible to measure the PLC radiation quite some distance from the wires. The Italian study[21] lists measurements up to 100 meters (310 ft) from the power line, while the Japanese study[10] measured up to 180 meters (550 ft) away.

The NATO study used a model that went beyond 200 meters (600 ft).[8]

The Swiss study[13] was not able to detect any PLC signals from a city, when 500 meters (1500 ft) outside the city. However, the Swiss power lines were probably buried, which would reduce the reach of the signals.[8]

The radio amateurs that complained about interference were up to 0.7 miles away from the power line.[7]

Radio observatories, however, would need to be miles away.[10]

Different brands of PLC systems will radiate differently, and the radiation will also greatly depend on the specific place. Some of these factors are discussed next.

The antenna effect depends on the situation

Antenna systems are complicated; the radiated effect depends on the frequencies, the current and the exact dimensions of the antenna. The electrical system of just a single home is complex. There are several branches of wires, which vary in length, change direction and have various equipment attached to them. The radiation can thus be expected to vary with the house, even in the same neighborhood.

The electrical distribution system for an area is also very complex. There are substations, power lines on poles or in the ground, which branch off in various directions. Older systems are also likely to have corroded connectors, which can generate arcing.

Whether the power lines are individual wires on poles, cables on poles or buried cables can also greatly influence the radiation levels.

The general wiring practices are another factor which vary by country. Continental Europe uses three-phase feeds to households, while Great Britain, Japan and the United States use two phase. In the United States, each transformer typically serves just a few households, while in Europe well over a hundred households are commonly served by one transformer.

The voltages vary, with higher voltages used on power distribution lines in the United States. Higher voltages may enhance the antenna effect.

There are several kinds of PLC systems available. Some are better suited to a certain wiring practice than others. The different PLC systems also produce different signals, and thus different radiation from the electrical system.

There are additional factors than these mentioned. For further discussion of this topic, see [6, 8].

Conclusion

There is much theoretical and practical evidence that PLC systems radiate wirelessly. This effect has been demonstrated both by laboratory studies as well as measurements on city-wide PLC systems. The effect has been demonstrated for many frequency bands and is not limited to particular PLC systems.

That PLC systems turn power lines and household wiring into de facto antennas is well established, though the strength of the emissions will depend on the specific situation.

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Docket No. E-00000C-11-0328 Smart Meters

Wireless interference from Power Line Communication in Japan

How a controlled test demonstrated that Power Line Communication (PLC) turns the power lines along the streets into unintended antennas. This test was instrumental in keeping restrictions on PLC in Japan.

Power line communication (PLC) is a method to transmit data using the existing electrical grid instead of fiber optic cables, telephone lines, dedicated lines or wireless communications. PLC can be used to bring internet services to households, for communication with smart electrical meters, or other uses.

The various PLC systems all work by injecting signals onto the electrical wires, which are then picked up elsewhere. The concern is that these added signals turn the electrical wires into unintentional antennas.

With many miles of power lines turned into antennas, even weak signals can have a substantial reach.

Early on, the authorities in Japan limited PLC systems to frequencies below 450 kHz. This limit was set as higher frequencies are used for civilian and military telecommunications, as well as by radio astronomy. These uses are not disturbed by radio noise below the 450 kHz. However, this limit was set as a precaution; it was originally not known whether there really would be a problem.

In the early 2000s, the PLC industry applied for permission to use frequencies up to 30 MHz, i.e. just below the VHF band. The ministry responsible for the wireless spectrum (Ministry of Public Management, Home Affairs, Post and Telecommunications) created a study group to look into the issue.

Testing PLC radio interference

An experiment was conducted by eight scientists from two universities, a space research center and the Japanese National Astronomical Observatory.

They created a test site on Mt. Akagi in a rural area of Japan. They had three power poles erected in a straight line, to simulate a small section of a residential power line.

Then they set up a small PLC network, using two laptop computers and PLC modems. One computer was connected to the middle pole on the simulated power line. The other computer was placed inside a shielded shed to simulate a house.

Five different PLC modems were used, covering the frequencies from 3.8 MHz to 20.9 MHz. To receive the signals radiating from the simulated power line, antennas, receivers and spectrum analyzers were used. The receiving antennas were placed from 35 meters (110 ft) to 180 meters (560 ft) from the power line.

Results

The scientists could clearly detect the PLC radiation from the simulated power line. The report states:

> *many broadcasting signals were interfered [with] and some of them completely masked by the PLC noise.*

They also noted that the PLC emissions were at least 30 dB above the cosmic radiation throughout the 4–30 MHz band.

As radio astronomy is very interested in the UHF band (300 MHz – 3 GHz), the study also looked at possible interference above 300 MHz. Even though the PLC systems all operated at frequencies below 21 MHz, they had a demonstrated spillover effect (harmonics) that clearly showed up at much higher frequencies.

The report concluded that a radio observatory must be located at least 4 km (2.5 miles) from the test site in order not to be disturbed. If PLC systems came into general use, using miles of power lines, a radio observatory must be located much further from populated areas. This would be impossible in densely populated Japan.

Conclusion

The conclusion was that PLC systems should not be allowed to use the requested frequencies, as it would interfere with telecommunication and science. The Ministry did not grant the permission.

Sources:

Measurements of Harmful Interference in the HF-UHF Bands Caused by Extension of Power Line Communication Bandwidth, Fuminori Tsuchiya et al, IVS CRL-TDC News, No. 21, November 2002.

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